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(54) **FUZZY LOGIC BASED MODEL ASSESSMENT SYSTEM AND METHOD FOR CONTACT TRACKING**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,860,214	A	* 8/1989	Mastsuda et al.	364/513
5,051,932	A	* 9/1991	Inoue et al.	364/550
5,245,528	A	* 9/1993	Satio et al.	364/161
5,251,285	A	* 10/1993	Inoue et al.	395/10
5,377,308	A	* 12/1994	Inoue et al.	395/61
5,410,470	A	* 4/1995	Yamaoka et al.	364/165
5,472,273	A	* 12/1995	Fowler et al.	366/69
5,493,729	A	* 2/1996	Nigawara et al.	395/61
5,581,490	A	* 12/1996	Ferkinhoff et al.	364/578
5,796,917	A	* 8/1998	Matranga et al.	395/3
5,819,007	A	* 10/1998	Elghazzawi	395/51
5,998,769	A	* 12/1999	Le Van Suu	219/506

* cited by examiner

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(57) **ABSTRACT**

A fuzzy logic based model assessment system assesses models of physical phenomena and in one example, is used for contact tracking. The system uses measurement residual values representing the difference between a measured data sequence corresponding to the physical phenomena and an expected data sequence corresponding to the model to be assessed. The system includes a feature identification module for identifying one or more features or tracking anomalies in the measurement residual values, such as jump and drift, and for generating feature amplitude values and feature amplitude standard deviation values. An anomaly characterization module characterizes the features in one or more membership classes representing the strength of the identified feature and generates class membership intervals representing a range of degrees of membership in each of the classes (e.g., null, weak, moderate or strong). A hypothesis formulation and evaluation module determines one or more possible causes of mismodeling by applying fuzzy inferencing to the class memberships, and generates hypothesis certainty intervals representing a range of degrees of certainty of the mismodeling hypothesis based on the class membership intervals. A knowledge base of heuristic rules are used to infer the mismodeling hypotheses based upon the membership classes.

26 Claims, 6 Drawing Sheets